Open-water autotrophs: Biomass and distribution in the deepwater basins of two experimental wetlands

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Introduction

Macroalgae and other open-water autotrophs (OWA) [e.g., coontails, (*Ceratophyllum* sp.), duckweed (*Lemna minor*), and pondweed (*Potamogeton* sp.)] were some of the first taxa to colonize the Olentangy River Wetland Research Park (ORW) experimental wetlands (Deal and Kantz, 1996). After emergent macrophytes have become dominant, the highest cover of OWA is found in the three deep-water basins of each wetland. Through a series of studies, Deal and Kantz (1996, 1999) examined the overall composition and abundance of algal species since the creation of Wetland 1 (W1) and Wetland 2 (W2). More recently, Deal and Kantz (2000 and 2001) have noted seasonal and yearly fluctuations and inter-relations of various algae genera and *Lemna minor*. It has been suggested in this and other research (Szabo et al. 1998) that some algae may inhibit Lemna species and vice versa.

Estimated net primary productivity has been evaluated at each experimental wetland since 1997 using representative 1- m^2 quadrats to measure emergant above ground biomass (Mitsch and Bouchard, 1998). Given the large surface area that the deep-water basins represent (approximately 25% of each wetland), the OWA component has the potential to contribute a significant amount to the yearly productivity of each system. Furthermore, it is likely that the high photosynthetic activity by OWA in these wetlands affects the physical (DO, pH) and chemical (Ca-P co-precipitation) water conditions of each wetland (Liptak and Mitsch, 1999).

The objective of this study was to 1) determine the distribution of various OWA at the end of the 2002 growing season, and 2) estimate/compare the biomass of OWA among deepwater basins in each wetland and between the two wetlands.

Methods

The deepwater basins in W1 and W2 were sampled for estimated biomass and cover by OWA on 29 August and 6 September 2002. Biomass sampling was conducted approximately 0.5 m from the boardwalk at a total of 60 designated sampling stations (Figure 1). The specific sampling spot within each station area was randomly determined along the boardwalk. For each station, all OWA biomass was collected inside a 642 cm^2 circular plot of the water column using a plastic cylinder. The cylinder was made by cutting the bottom of a 5-gallon bucket (28.6 cm diameter and 34.9 cm long). The cylinder was carefully placed perpendicularly into the water so one end was inserted on the wetland bottom and the other end protruded out of the water. Once the cylinder was in place, water was slowly baled out of it, including all OWA. The contents of the cylinder were sieved through a 1 mm screen mesh and all screened biomass was separated by taxa, bagged and returned to the OSU Wetland Ecology laboratory. For each basin, the surface cover by each type of surface OWA was estimated along with general notes regarding basin conditions and possible factors influencing it.

At the laboratory, sampled OWA was sorted by taxonomic type with no attempt made to separate different species of filamentous algae species. In some instances, filamentous algae was entangled with other submerged aquatic plants, and the two samples could not be feasibly separated. In these cases, the percent contribution of each specimen to the total sample biomass was estimated. Each biomass sample was air-dried for one week and then oven dried at 105∞C for 48 hours. The biomass for each OWA sample was measured to the nearest 0.1 g. Biomass weights for each sampling plot were converted to 1 m^2 for reporting and comparison purposes. All statistical comparisons of biomass means were conducted using standard two-tailed, paired t-test.

Representative algae/water samples were collected from each basin and sent to Dr. Robert Deal at Shawnee State University, Department of Natural Sciences for identification of macroalgae and any microalgae that may be present. For this analysis, each sample was placed in a prep dish, spread out, and scanned at 7 - 25x under a stereomicroscope. A composite microscope slide mount was then made taking material from several places in the sample, then observed on a Nikon Eclipse 600 compound microscope using 40, 100 and 200x, observing and recording everything under the coverslip.

Results and Discussion

Deepwater Basin Biomass Estimations

OWA during the sampling event was dominated by four taxa: coontail (*Ceratophyllum* sp.), duckweed (*Lemna* sp.), filamentous algae (dominated by *Hydrdictyon* sp. and *Cladophora* sp.) and pondweed (*Potamogeton* sp.). Collectively, biomass was distributed in a very distinct longitudinal pattern for both W1 and W2 (Figure 2) with

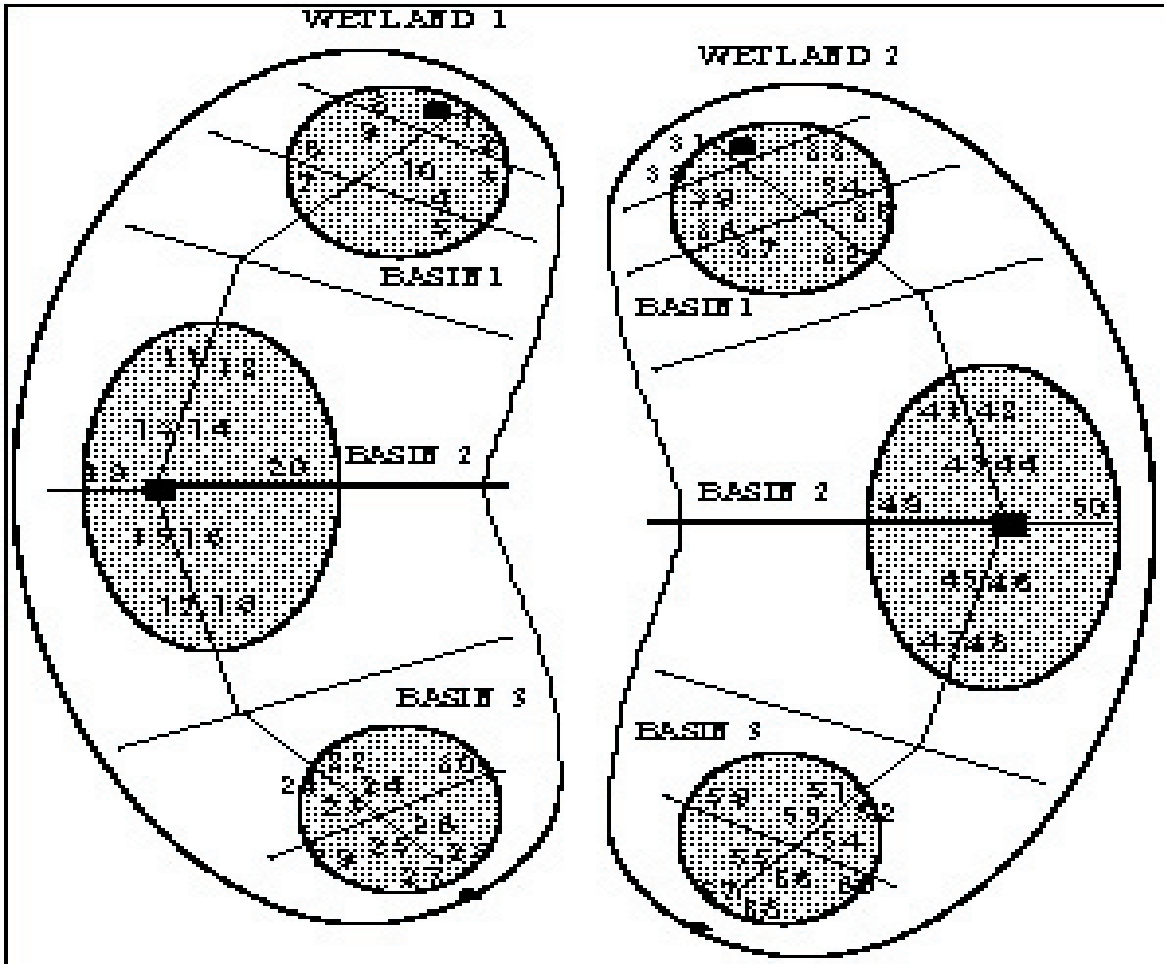

Figure 1. Location of deepwater basins and OWA biomass sampling stations in W1 and W2.

moderate biomass (77.6 ±14.2 g/m^2 and 41.5 ±10.8 g/m^2, respectively) in the inflow basins (W1B1 and W2B1), high biomass (120.3 ±11.4 g/m^2 and 122.6 ±14.0 g/m^2, respectively) in the middle basins (W1B2 and W2B2) and moderate-to-low biomass (63.2 ±9.5 g/m^2 and 16.2 ±16.2 g/m^2, respectively) in the outflow basins (W1B3 and W2B3) (Figure 2). When the biomass is calculated for each wetland, W1 had a significantly greater mean OWA biomass in its basins (87.0 ± 8.0 g/m^2) than W2 (60.1 ± 11.4 g/m^2) (p=0.03).

Although the constituents of biomass were different at each wetland (see results below), the similarity of high biomass amounts in the middle basin of W1 and W2 suggests that nutrient availability is highest in these areas. This is a little surprising given the inlet basins are the first to receive the river inflow. One explanation may be that turbid conditions in the inflow area may impede algae development. The turbidity is a product of an already turbid river water source and the additional turbidity caused by water falling from the inflow pipe. This area may be more conducive to *Lemna* (a surface-growing plant) than algae growing in the water column. This explanation is somewhat supported in the recent analyses of OWA, where more recently high levels of *Lemna* biomass have been observed in the inlet basins (Deal and Kantz 2000).

OWA Biomass and Abundance Estimations

Lemna and algae represented the highest amounts of OWA measured in W1 and W2, respectively. *Lemna* biomass was highest in W1B2 (113.0 ±8.5 g/m^2) and algae biomass was highest in W2B2 (99.5 ±14.6 g/m^2) (Figure 3). *Lemna* was also moderately high in W1B1 (68.3 ±11.1 g/m^2), but only trace amounts were found in all other basins (Figure 3). Cover by *Lemna* in W1B1 and W1B2 was visually estimated at 100 percent. Significant cover (30%) of *Lemna* was also estimated in W2B1 however only trace amounts were collected in eight of the ten stations sampled. Algae were lowest in both the inlet basins of W1 and W2 (Figure 3). Algae biomass increased longitudinally in W1 from 1.2 ±0.4 g/m^2 in W1B1 to 35.9 ±8.5 g/m2 in W1B3. It was also noted that in W2B2, where algae levels were exceptionally high, there was evidence of significant waterfowl excrement on

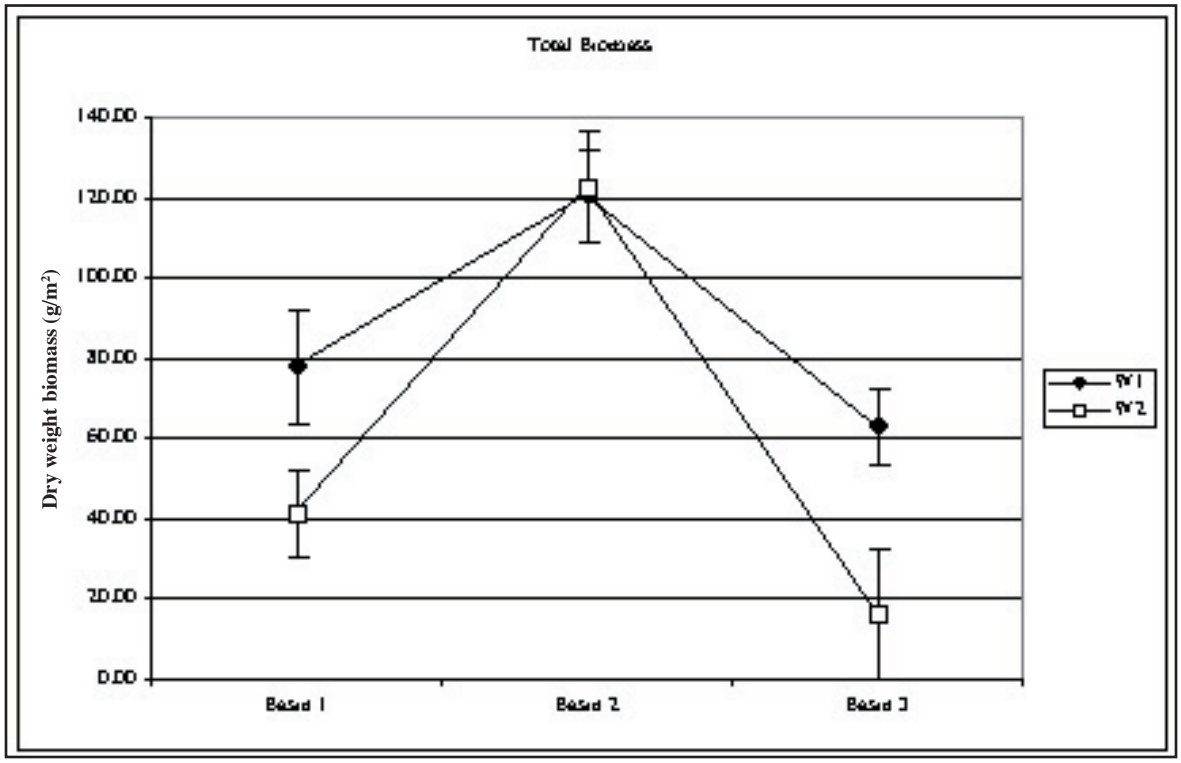

Figure 2 Total mean biomass (±SE) of OWA (g/m^2) in W1and W2 as observed in September 2002.

the boardwalk. *Ceratophyllum* and *Potamogeton* biomass was collected throughout W1 and W2, but only minimal amounts of each were measured (Figure 3).

The biomass and abundance of OWA in W1 and W2 are consistent with recent results collected in 1999 and 2000 by Deal and Kantz. In September 1999, they found high cover (100%) for *Lemna* in both W1B1 and W2B1 (along with minimal amounts of *Cladophora*), but no cover and highly scattered cover in W1B3 and W2B3, respectively (Deal and Kantz 2000). Likewise, in September 2000, they found heavy (but decreasing compared to the month before) levels of *Lemna* in W1B1 and W2B1. They also reported 'considerable' cover by *Lemna* continued in the middle basins with only scattered amounts in W1B3 and over 20% cover in W2B3. Algae were observed throughout all the basins, but the highest coverage (75%) was observed in W2B3. In most observations of the inlet and middle basins, there was a negative correlation between the amount of algae and *Lemna* present (Deal and Kantz 2000).

The information collected at the ORW wetlands suggests that the interaction between various algae species and *Lemna* is complex. There is evidence from outside research that micro and macroalgae inhibit *Lemna* production through nutrient removal and potential antibiotic chemical release (Szabo et al. 1998). Likewise, *Lemna* has been shown to inhibit algae production through shading and the excretion of allelochemicals (Szabo et al. 1998). Szabo et al. (1998) examined the interaction of *Lemna* with various algae species and found that high organic loading inhibited *Lemna* production, particularly if coverage was already below 50 percent. If *Lemna* cover stayed above 50 percent, the shading effect likely inhibited the competitive influences of algae.

In addition to nutrient loads, it is possible that climatic and faunal factors may be important. Deal and Krantz (2000) suggest that *Lemna* cover can be significantly altered by the result of strong prevailing winds. Wetlands with less macrophytic cover around the deep water basins may be more exposed to wind which could push *Lemna* out of the basin and reduce cover below 50 percent, hence giving algae an opportunity to become established. Waterfowl may also have an influence on *Lemna*-algae dynamics. Various cyanobacteria species are known to contain extracts that inhibit *Lemna* production (Szabo et al. 1998). Through microalgae censuses, Deal and Kantz (2000) have identified increased occurrences of cyanobacteria in the basins more frequented by geese and ducks (as evident by droppings on the boardwalk). In this study, high amounts of goose/duck excrements were observed on the W2B2 boardwalk where the highest levels of algae biomass were measured. A third possible factor is the decrease in water turbidity from inflow to outflow that may give *Lemna* a decided advantage in the basins closer to the inflow. All the factors discussed, and others unknown, likely influence the *Lemna*-algae dynamics and more extensive research of this ecological relationship is needed.

References

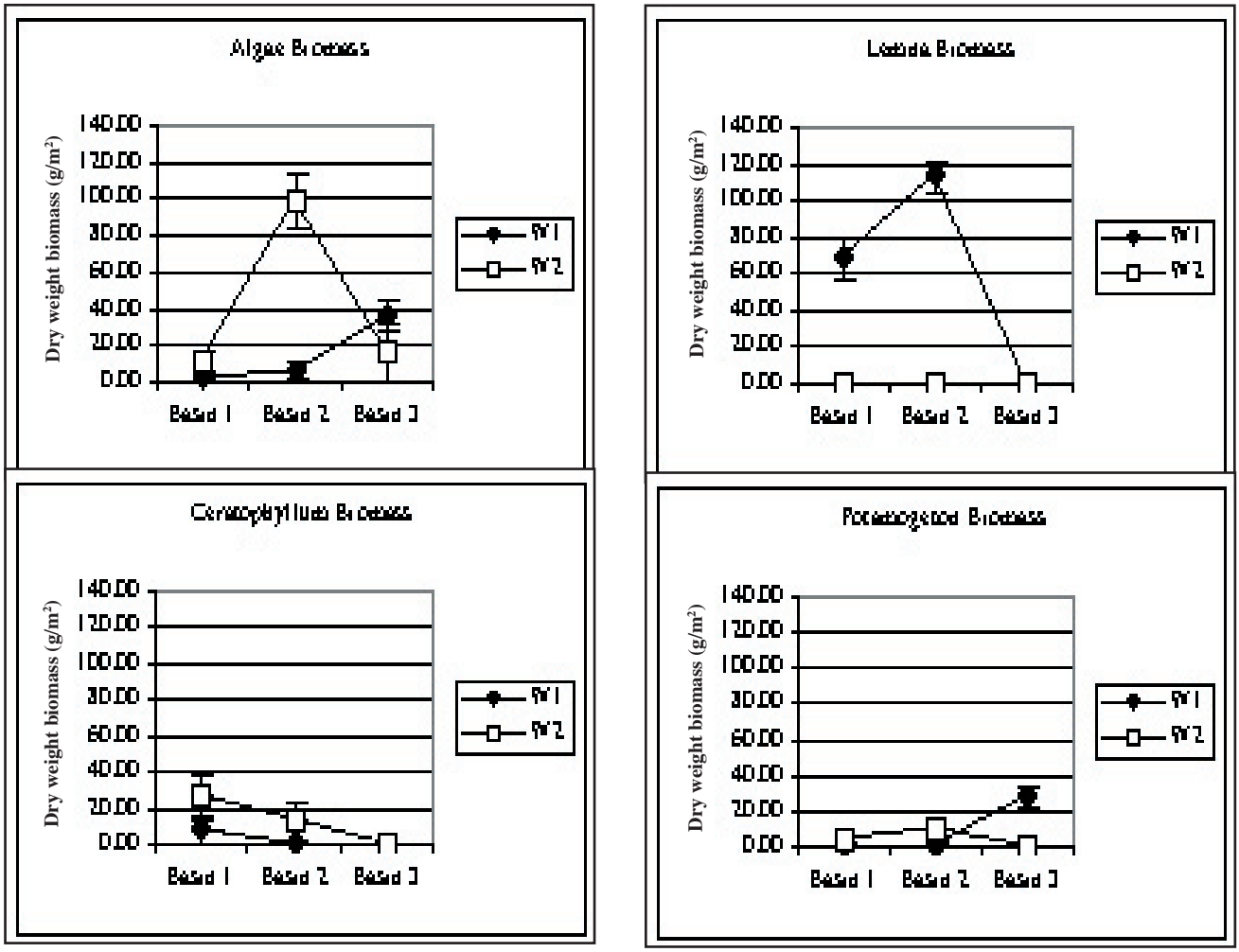

Figure 3. Total mean biomass (±SE) of macroalgae, Lemna, Ceratophyllum, and Potamogeton (g/m²) in W1 and W2 as observed in September 2002.

Deal, R. and J. A. Kantz. 1999. Comparison of macroalgal dominants in the two Olentangy River experimental wetland basins. In: W. J. Mitsch and V. Bouchard (eds.), The Olentangy River Wetland Research Park at The Ohio State University, Annual Report 1998. The Ohio State University, Columbus, OH, pp. 77-78.

Deal, R. and J. A. Kantz. 1996. Seasonal and successional trends in algal diversity and population dynamics in constructed wetlands . In: W. J. Mitsch (ed.), The Olentangy River Wetland Research Park at The Ohio State University, Annual Report 1995. The Ohio State University, Columbus, OH, pp. 137-140.

Deal, R. and J. A. Kantz. 2000. Summer mat macroalgae largely replaced by duckweed, Lemna minor, in 1999 in two Olentangy River experimental wetlands. In: W. J. Mitsch and L. Zhang (eds.), The Olentangy River Wetland Research Park at The Ohio State University, Annual Report 1999. The Ohio State University, Columbus, OH, pp. 61-64.

Deal, R. and J. A. Kantz. 2001. Algal and Lemna continue to fluctuate seasonally and basin-to-basin in the Olentangy River wetlands. In: W. J. Mitsch and L. Zhang (eds.), The Olentangy River Wetland Research Park at The Ohio State University, Annual Report 2000. The Ohio State University, Columbus, OH, pp. 61-63.

Liptak, M. A. and W. J. Mitsch. 1999. Algal-induced calcite and phosphorus coprecipitation. In: W. J. Mitsch and V. Bouchard (eds.), The Olentangy River Wetland Research Park at The Ohio State University, Annual Report 1998. The Ohio State University, Columbus, OH, pp. 183-190.

Mitsch, W. J. and V. Bouchard. 1998. Net primary productivity in experimental marshes. In: W. J. Mitsch and V. Bouchard (eds.), The Olentangy River Wetland Research Park at The Ohio State University, Annual Report 1997. The Ohio State University, Columbus, OH, pp. 71-75.

Szabo, S., M. Braun, S. Balazsy, and O. Reisinger. 1998. Influences of nine algal species isolated from duckweed-covered sewage minipods on *Lemna gibba* L. Aquatic Botany 60: 189-195.